

# Scapholunate Diastasis in Distal Radius Fractures: Fracture Pattern Analysis on CT Scans

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J Wrist Surg 2020;9:338–344.

## Abstract

**Objectives** Our understanding of distal radius fractures with concomitant scapholunate (SL) diastasis primarily comes from plain radiographs and arthroscopy. The clinical implications of SL diastasis are not clear. The aim of this study is to describe fracture characteristics of distal radius fractures on computed tomography (CT) scans in patients with distal radius fractures and static SL diastasis.

**Methods** We queried our institutional databases to identify patients who were treated for a distal radius fracture, had a CT scan with a wrist-protocol, and static SL diastasis on their CT scan. Our final cohort consisted of 26 patients. We then collected data on their demographics, injury, treatment, evaluated injury patterns, and measured radiographic SL characteristics. Our study cohort consisted of 11 men (42%) and almost half of our cohort ( $n = 12$ ; 46%) had a high-energy mechanism of injury. The majority of the patients ( $n = 20$ ; 77%) had operative treatment for their distal radius fracture and two patients (7.7%) had operative treatment of their SL injury.

**Results** The mean SL distance was  $3.5 \pm 1.1$  mm. Twenty patients (77%) had an intra-articular fracture. In these patients, we observed three patterns: (1) scaphoid facet impaction; (2) lunate facet impaction; and (3) no relative impaction. We observed other injury elements including rotation of the radial styloid relative to the lunate facet and partial carpal subluxations.

**Conclusion** Static SL dissociation in the setting of distal radius fractures may be an indication of a complex injury of the distal radius, which may not be directly apparent on plain radiography. If these radiographs do not demonstrate impaction of the lunate or scaphoid facet, a CT scan may be warranted to have a more detailed view of the articular surface.

**Level of Evidence** This is a Level III, diagnostic study.

## Keywords

- ▶ distal radius fractures
- ▶ injury pattern
- ▶ CT scan
- ▶ scapholunate diastasis

Scapholunate interosseous ligament (SLIL) injury is common in distal radius fractures.<sup>1,2</sup> It has been suggested that SLIL injury may be associated with intra-articular distal radius fractures,<sup>2–4</sup> high-energy shearing type fractures,<sup>5</sup> and

younger age.<sup>6,7</sup> However, it is unclear how SLIL injury influences the outcome of distal radius fractures.<sup>2,8–10</sup>

Cadaveric studies demonstrated that scapholunate (SL) diastasis results from injury to multiple ligaments rather

received  
September 10, 2018  
accepted  
April 7, 2020  
published online  
June 9, 2020

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Tel: +1(212) 760-0888.

DOI <https://doi.org/10.1055/s-0040-1712505>.  
ISSN 2163-3916.

than SLIL injury in isolation,<sup>11</sup> and SL diastasis does not necessarily lead to carpal malalignment due to the role of secondary carpal stabilizers.<sup>12</sup> Biomechanical evidence suggests that a tear of the SLIL accompanied by a tear of the secondary stabilizers such as the dorsal radiocarpal ligament, volar radiocarpal ligaments, or scaphotrapezial ligaments may lead to greater carpal instability.<sup>13,14</sup>

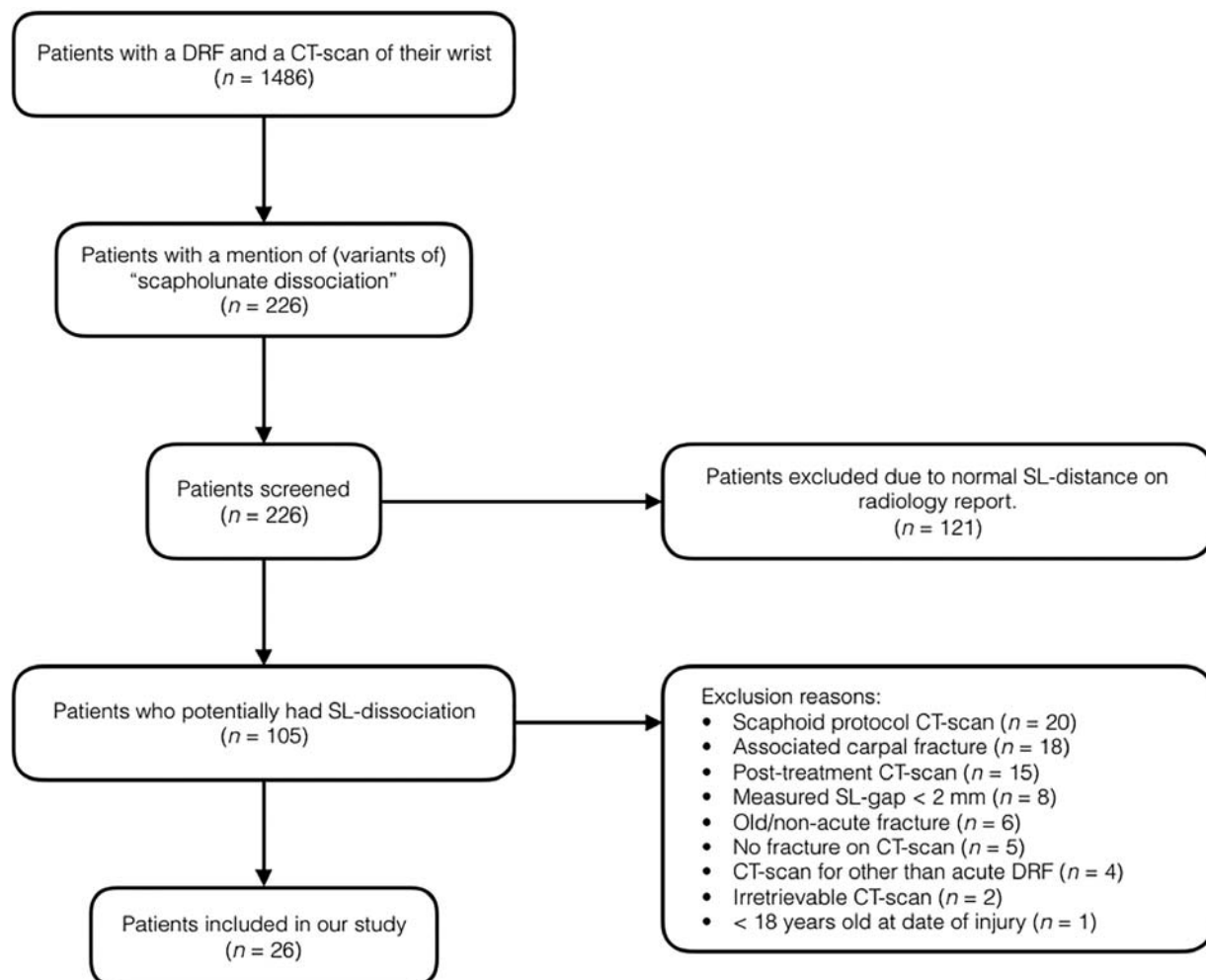
Fracture lines tend to occur between ligament attachment sites of the distal radius,<sup>15</sup> and intra-articular fractures often result in insufficiency of secondary stabilizers of the carpus.<sup>3</sup> Subsequently, SL diastasis in distal radius fractures may be related to displacement of these fracture fragments. The aim of this study is to describe fracture characteristics of distal radius fractures on computed tomography (CT) scans in patients with distal radius fractures and static SL diastasis.

## Methods

Our Institutional Review Board approved this retrospective study under protocol #2009P001019. To identify our cohort, we performed a coding search across two academic hospital systems in a single metropolitan area in the United States from 2005 to 2015. We included all patients who: (1) were treated for a distal radius fracture; (2) had a CT scan protocol for the

wrist; and (3) had SL diastasis on their CT scan. We identified these patients through current procedural terminology (CPT) codes for treatment of distal radius fractures by means of closed treatment (25600 or 25605), external fixation (20690 or 20692), percutaneous Kirschner wire pinning (25606), or open reduction internal fixation (25607–25609). Of these patients, 1,486 had a CT scan of their wrist.

We did the text search of the radiology reports of each of these scans for “scapholunate dissociation” or “SL dissociation” and possible variants and misspellings, which resulted in 226 patients. We then reviewed the medical records, radiographs, and CT scans to identify all patients who potentially had SL diastasis, resulting in an initial cohort of 105 patients. Exclusion criteria consisted of: (1) scaphoid protocol CT, as comparing measurements taken in planes that were not formatted identically would not be a valid comparison of SL diastasis; (2) carpal fractures, as we wanted to focus on the clinical scenario of a distal radius fracture with static SL dissociation, without having the carpal relations being altered by carpal fractures; (3) posttreatment CT scan; (4) an SL gap <2 mm; (5) nonacute fracture; (6) no fracture; (7) CT scan for an indication other than an acute distal radius fracture (e.g., bone tumor); (8) irretrievable CT scans; and (9) younger than 18 years old (►Fig. 1). Our final cohort consisted of 26 skeletally mature



**Fig. 1** Overview of inclusions and exclusions. CT, computed tomography; DRF, distal radius fracture; SL, scapholunate.

patients with a distal radius fracture and SL diastasis on CT scan. The mean number of days between the injury and the acquisition of a CT scan was  $3.8 \pm 6.2$  days.

The distance between the scaphoid and the lunate was measured on coronal views of the CT scan by the first and the senior author.<sup>16</sup> SL dissociation was defined if the narrowest distance between the scaphoid and the lunate bone on CT scan measured more than 2.0 mm on coronal views.

We used the lateral view of the pretreatment radiographs to measure the SL and radiolunate angle and to assess for volar and dorsal intercarpal segmental instability (DISI). In one patient who was treated nonoperatively, there were no pretreatment radiographs available and we, therefore, used the follow-up radiographs that were taken 8 weeks after his injury.

### Patient Characteristics

Our cohort consisted of 11 men (42%) and 15 women (58%) who were treated by a total of 12 surgeons. In 12 patients (46%), the injury involved the dominant hand. The mean age at the time of injury was  $56 \pm 18$  years. Twelve patients (46%) fractured their wrist due to a high energy mechanism of injury (motor vehicle accident, fall from higher than standing height, or sports injury). All injuries were closed injuries (►Table 1).

Six patients (23%) had nonoperative treatment of their distal radius fracture. The remaining twenty patients (77%) underwent open reduction and plate fixation for their distal radius fracture. Of those, seven patients (35%) underwent

dorsal plating and 13 patients (65%) underwent volar plating. The mean number of days from injury to surgery was  $6.9 \pm 5.3$  days. Two patients (7.7%) had simultaneous operative treatment of their SLIL injury (►Table 1). The surgical procedures that were performed for SLIL repair were pinning and Mitek suture anchor repair, respectively. Of the operatively treated patients, two patients (10%) had unplanned plate removal for symptomatic implants, and one patient (5%) had revision fixation with dorsal plating due to fixation failure of the volar plate that was initially used.

### Results

Four patients had an extra-articular fracture (15%), two patients had a partial articular fracture (7.7%), and 20 patients (77%) had a complete articular fracture (►Table 2). When an articular step-off was noted, the average depth was  $2.9 \pm 1.8$  mm and the gap was  $1.8 \pm 0.9$  mm. Four patients (15%) had a large intra-articular step-off that was not apparent on the radiographs (►Fig. 2).

We observed three patterns among patients with an articular fracture: (1) scaphoid facet impaction relative to the lunate facet ( $n = 7$ ; ►Fig. 2); (2) lunate facet impaction relative to the scaphoid facet ( $n = 1$ ; ►Fig. 3); and (3) no impaction of one facet relative to the other ( $n = 14$ ; ►Table 3). Fourteen patients had no relative impaction, meaning that either the scaphoid facet and the lunate facet were impacted as a whole ( $n = 3$ ) or that both the scaphoid facet and the lunate facet were not impacted at all ( $n = 11$ ). Of the seven patients with scaphoid facet impaction but no lunate facet impaction, three patients had a pronated radial styloid fragment, one had a supinated fragment, and two had a comminuted or split radial styloid fragment. Of the three patients with scaphoid facet and lunate facet impaction as a whole, the radial styloid fragment did not have an appreciable rotation in one patient, was supinated in the other, and was split or comminuted in the third patient (►Table 4).

The mean SL distance on the CT scan was  $3.5 \pm 1.1$  mm. The mean SL angle on plain radiographs was  $62 \pm 13$  degrees, and the mean radiolunate angle was  $6.5 \pm 12$  degrees.

**Table 1** Patient, injury, and treatment characteristics

	All patients
Variable	( $n = 26$ )
Patient characteristics	
Age, mean $\pm$ SD, y	$56 \pm 18$
Sex, $n$ (%)	
Men	11 (42)
Women	15 (58)
Obesity, $n$ (%)	6 (23)
Alcohol abuse, $n$ (%)	2 (7.7)
Tobacco, $n$ (%)	1 (3.9)
Injury characteristics	
High energy trauma, $n$ (%)	12 (46)
Affected side, $n$ (%)	
Left	13 (50)
Right	13 (50)
Dominant side involved <sup>a</sup> , $n$ (%)	12 (46)
Treatment characteristics	
Operative treatment of distal radius fracture, $n$ (%)	20 (77)
Scapholunate repair, $n$ (%)	2 (7.7)

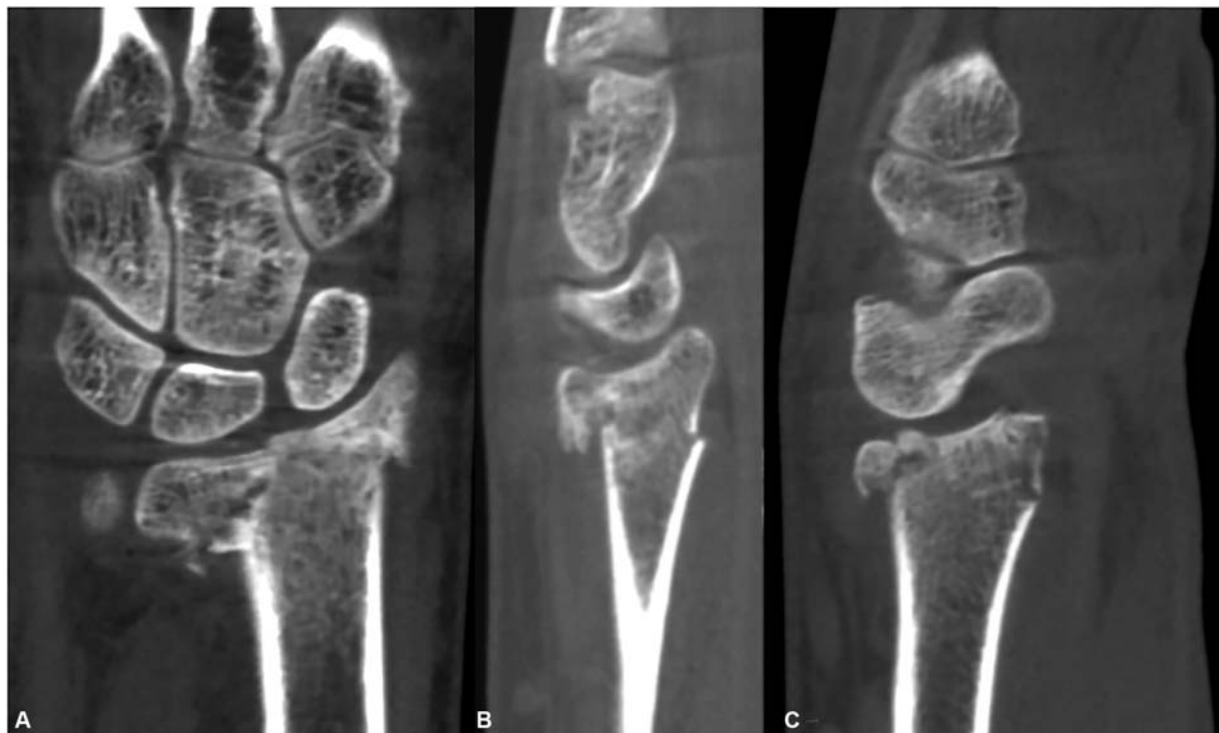
<sup>a</sup>Data not extractable from medical charts in five patients.

**Table 2** Fracture characteristics

	All patients
Variable	( $n = 26$ )
Fracture type, $n$ (%)	
A	4 (15)
B	2 (7.7)
C	20 (77)
Scapholunate gap, mean $\pm$ SD, mm	$3.5 \pm 1.1$
Articular gap, mean $\pm$ SD, mm	$2.9 \pm 1.8$
Articular step, mean $\pm$ SD, mm	$1.8 \pm 0.93$
Scapholunate angle, (degree)	$62 \pm 13$
Radiolunate angle, (degree)	$6.5 \pm 12$



**Fig. 2** A 31-year-old man with a partially articular left distal radius fracture due to a motor vehicle accident, which was treated with ORIF. The preoperative SL-gap was 7.1 mm. The presented injury could represent either an impaction fracture or a greater arc-variant. (A, B) Post-reduction PA- and lateral views of the plain radiographs. An articular step-off is not immediately apparent, while the coronal view of the CT-scan (►Fig. 2A) demonstrates an intra-articular step-off. (C) Coronal view of the preoperative CT-scan demonstrated impaction of the scaphoid facet. (D) Sagittal view illustrating a dorsal intercarpal segmental instability. The capitate has remained associated with the scaphoid, as it subluxates from the lunate. (E) Sagittal view illustrating subluxation of the scaphoid from the scaphoid fossa. CT, computed tomography; ORIF, open reduction internal fixation; PA, posteroanterior; SL, scapholunate.



**Fig. 3** A 52-year-old woman who sustained a left multifragmented intra-articular distal radius fracture during sports activities, which was treated with ORIF. The preoperative SL-gap was 2.7 mm. (A) Coronal view of the preoperative CT-scan demonstrated impaction of the lunate facet. (B) Sagittal view, demonstrating the lunate has remained associated with the lunate facet, subluxating volarly. (C) Sagittal view, the scaphoid is subluxating from the scaphoid facet/radial styloid, dorsally. CT, computed tomography; ORIF, open reduction internal fixation.

In complete articular fractures, we observed partial carpal subluxations where the lunate subluxated volarly with the facet, while the scaphoid remained associated with the radial styloid fragment (►Fig. 3). Partial dorsal and volar carpal subluxations were apparent in five (19%) and four (15%) patients, respectively (►Table 5).

There were three patients (14%) with a DISI (►Fig. 2). Of the three patients with DISI, which was defined as the

combination of a noncollinear axis of the capitate and dorsal tilt of the lunate, one patient (33%) had no radial styloid fragment but dorsal carpal subluxation, one (33%) had an unimpacted radial styloid fragment with dorsal carpal subluxation, and one patient had an impacted radial styloid fragment without a subluxation of the carpus. No patient with a volar intercarpal segmental instability posture was observed.

**Table 3** Three fracture patterns of 22 fractures with (partial) articular involvement

Pattern	n (%)
Scaphoid facet impaction without lunate facet impaction	7 (27)
Lunate facet impaction without scaphoid facet impaction	1 (3.9)
Complete articular, but no impaction of scaphoid or lunate relative to each other	14 (54)

**Table 4** Radial styloid fragment characteristics in patients with scaphoid facet impaction

Pattern	n
Scaphoid facet impaction without lunate facet impaction	
No rotation of radial styloid fragment	1
Pronated radial styloid fragment	3
Supinated radial styloid fragment	1
Comminuted or split radial styloid fragment	2
Scaphoid facet and lunate facet impacted as a whole	
No rotation of radial styloid fragment	1
Supinated radial styloid fragment	1
Split or comminuted radial styloid fragment	1

**Table 5** Appreciation of partial carpal subluxations

Pattern	n
Scaphoid facet impaction without lunate facet impaction	
Volar subluxation	2
Lunate facet impaction without scaphoid facet impaction	
Dorsal subluxation	1
No impaction of scaphoid or lunate facet relative to each other	
Scaphoid facet and lunate facet impacted as a whole	
Dorsal subluxation	2
Volar subluxation	1
Both scaphoid and lunate facet not impacted	
Dorsal subluxation	2
Volar subluxation	1

## Discussion

We analyzed 26 CT scans of patients with distal radius fractures and SL diastasis. In 30% of the intra-articular fractures, there was a large intra-articular step-off present. Partial subluxations of the carpus were observed in nine cases: five patients (19%) had dorsal subluxation and four patients (15%) had volar subluxation.

The primary limitation of this study is its descriptive nature. We did not seek to obtain clinical outcomes post-

surgery, and this study is aimed to characterize only radiographic data. We began with a large retrospective cohort of CT scans of distal radius fractures and narrowed this cohort to identify unambiguous cases of distal radius fractures with SL dissociation. We eliminated cases using very strict inclusion criteria, but felt that in this type of descriptive study, we could only find meaningful results if the included data were strictly selected. We likely excluded several cases of actual distal radius fracture with SL dissociation who underwent a scaphoid protocol CT scan, but we felt that it would be difficult to quantify SL diastasis and articular step-offs in a standardized manner using these views. Second, our data do not provide insights into the incidence of SLIL injury, as we do not know how many patients had distal radius fractures with SL diastases, who did not undergo a CT scan. Although we had a small cohort of patients, we were able to capture accurate data from an uncommon injury pattern from the catchment of two level I academic medical centers in a large metropolitan area over the course of 10 years.

It is also important to recognize that all of these cases were SLIL injuries with static dissociation. We did not aim to study cases with dynamic instability, and these results cannot be extrapolated to those situations. Although the pattern of injury was interpreted by two observers, quantitative measurements were performed to mitigate bias or subjective interpretation. It is difficult for surgeons to determine what constitutes SL diastasis radiographically in the setting of distal radius fracture. Gradl et al found a positive predictive value of 68% and a negative predictive value of 84% when surgeons used radiographs to diagnose SL diastasis in the setting of an AO type C distal radius fracture versus the reference standard of a CT arthrogram.<sup>17</sup> CT scanning without arthrography has been studied as an alternative means of diagnosing SL dissociation.<sup>16</sup> We did not have contralateral radiographs in most cases and were not able to make any comment on the presence of natural variation of SL diastasis.<sup>12</sup> Adequate acquisition and interpretation of three-dimensional visualization of intercarpal relationships in the setting of distal radius fracture is difficult.

Our findings are important because it indicates that in patients with static SL dissociation, a large intra-articular step-off may not be sufficiently appreciable on radiographs (► Fig. 2). When assessing these fractures on CT scans, the radial styloid was frequently rotated, leaving a larger step-off dorsally or volarly. The degree of step-off may be underestimated on plain radiographs because the viewer will generally see the contrast between the higher joint surface and the radiolucent soft tissues.

Geissler and colleagues described their experience with arthroscopic-assisted distal radius internal fixation and found that the patients with intercarpal soft tissue injuries generally had an AO C-type fracture of the distal radius.<sup>1,18</sup> Arthroscopic studies by Fontes et al also suggest that radial styloid process fractures or complete articular fractures are associated with SLIL injury.<sup>19</sup> Our findings are an extension of these previous studies: static SL diastasis is generally interpreted as a more severe injury to the SLIL. It follows that distal radius fractures

with large step-offs would be anticipated when a larger SLIL is present.<sup>9</sup>

Traditionally, SL dissociation has been conceptualized as part of a perilunate injury, and SL injury in the setting of a distal radius fracture has been seen as a greater arc perilunate injury.<sup>20</sup> However, Mudgal and Hastings suggest that some cases of SL dissociation in the setting of distal radius fracture occur due to other mechanisms such as the impaction of the carpus on the radius.<sup>3</sup> It is likely that in these cases the SL injury and the insufficiency of secondary stabilizers such as the dorsal radiocarpal ligament or the volar extrinsic ligaments lead to static SL dissociation. Bain et al have demonstrated that fractures generally occur between the attachment sites of the extrinsic ligaments.<sup>15</sup> It is likely that in most cases where the SL ligament has been injured, there is a limited residual carpal instability because the bony attachment of these secondary stabilizers heals.

However, in study of the CT scans, we observed complex articular injury patterns. We observed partial carpal subluxations where the lunate facet or the scaphoid facet was subluxated volarly or dorsally while the other facet was not. We also observed a variety of injury patterns where the radial styloid was malrotated and there were some cases with an acute DISI posture. Volar plate fixation without specific attention to styloid rotation may result in malreduction of the styloid in these cases despite apparently radiographically acceptable parameters.

Overall, our data suggest that static SL dissociation in the setting of a distal radius fracture may indicate a more complex injury to intra-articular distal radius fractures than may be apparent on plain radiographs. In patients with static SL dissociation and a distal radius fracture, CT scanning may provide valuable information about fracture elements and may reveal that the scaphoid facet and lunate facet may be substantially displaced and malrotated relative to one another. When this occurs, careful reduction may be needed to restore anatomical relationships of the articular surface as well as the carpus.

#### Note

The work was performed at the Hand and Upper Extremity Service, Department of Orthopedic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, United States.

#### Ethical Approval

The Institutional Review Board of our institution approved this study under protocol 2009P001019.

#### Authors' Contributions

This study represents a great deal of effort, resources, and dedication on the part of the authors in reviewing and reconstructing all cases, reviewing the literature, and performing statistical analyses. All authors have participated in a material way to the elements below:

S.O., N.C.C., J.B.J., C.S.M., and F.W.B. participated in the study design. S.O. and N.C.C. gathered study Data. S.O., N.C.C., J.B.J., C.S.M., and F.W.B. performed data analysis. S.O., N.

C.C., J.B.J., C.S.M., and F.W.B. prepared initial draft. S.O. and N.C.C. ensured accuracy of data

#### Conflict of Interest

None declared.

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